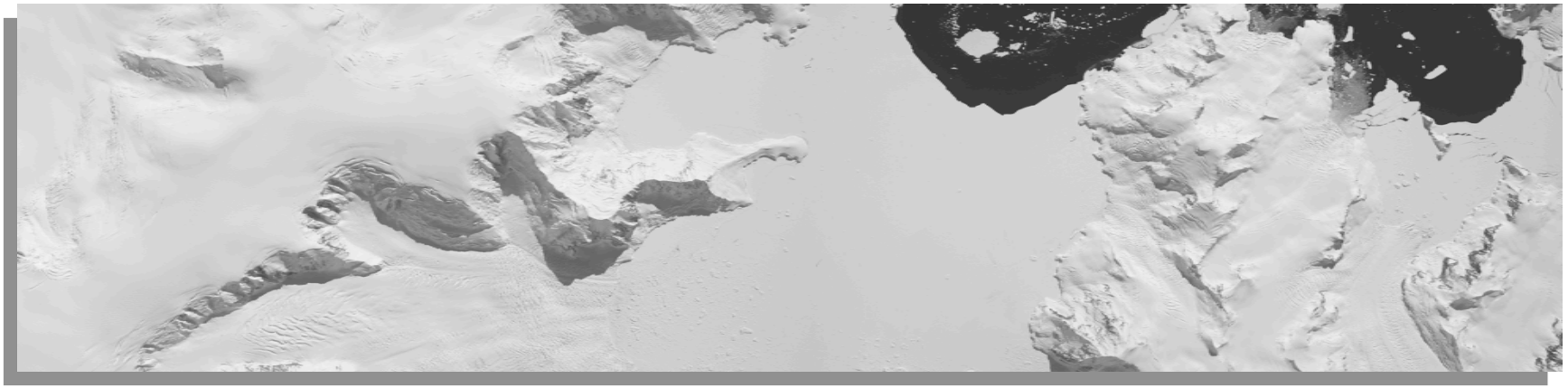

DMS
Digital Mapping System

DEM Extraction from Multi-view Imagery

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Ryan Dotson
Toni Schenk

Ice Bridge Science and Planning Meeting

January 27, 2010

The Digital Mapping System (DMS)

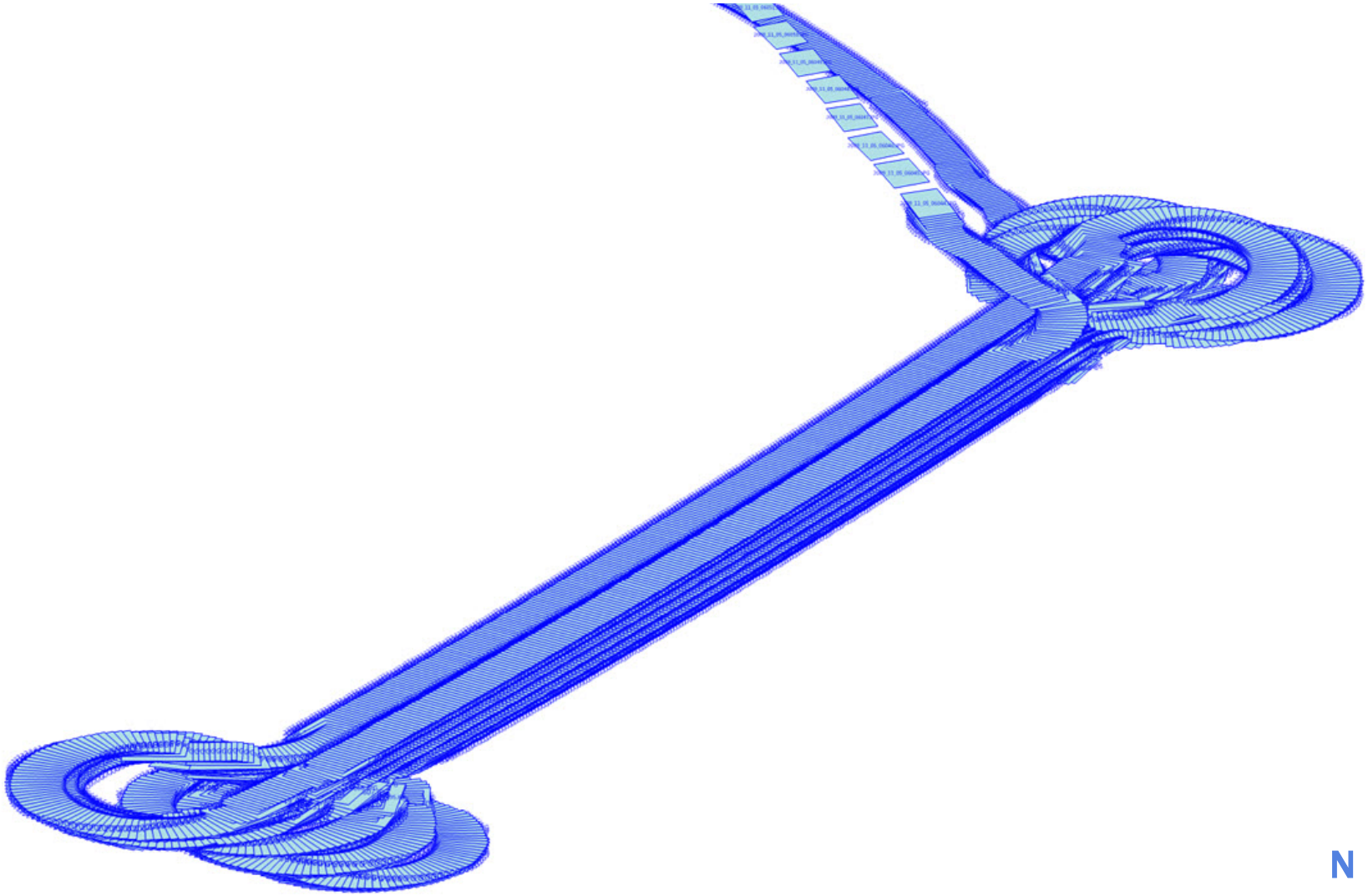
- Nadir-viewing 21Mpixel digital camera of latest technology
- Multi-core laptop computer with SATA hard drive (now SSD)
- DMS produces a timing pulse that triggers an Applanix “Event” record
  - Accurate correlation with camera GPS position and view vector
- Frame rate at ATM flight altitude: >1 per second (continuous)
  - Required for adequate stereo coverage at ATM flight altitude / speed
- Pixel resolution / image coverage
  - ATM Flight Altitude: 10cm / 570 x 380 meters
  - LVIS Flight Altitude: 2.5m / 13km x 9km
- Along-flight field of view: 64º (providing excellent stereo parallax)
- Geo-rectification is accomplished post-flight, but could be implemented in real-time

DMS Ice Bridge Applications

- Extraction of high-resolution DEM
- Creation of high-resolution 3-D imagery
- Synergistic merging with LIDAR-derived DEM
- Ice surface metrology

DMS Image Coverage

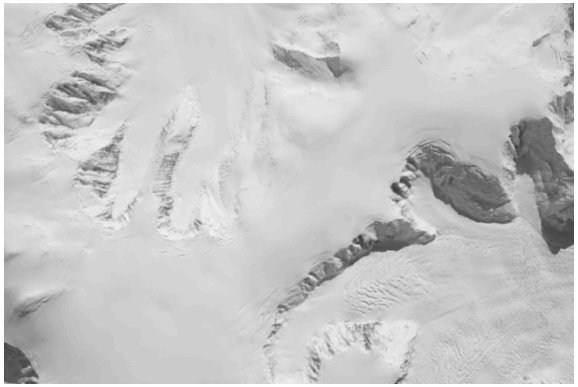
Crane Glacier Flight 11/5/2009



DMS Multi-view Example

Crane Glacier Flight

1



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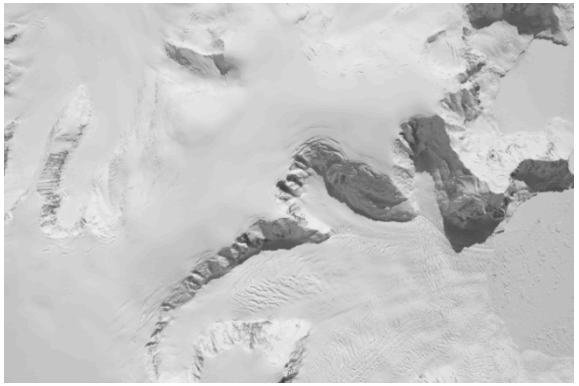

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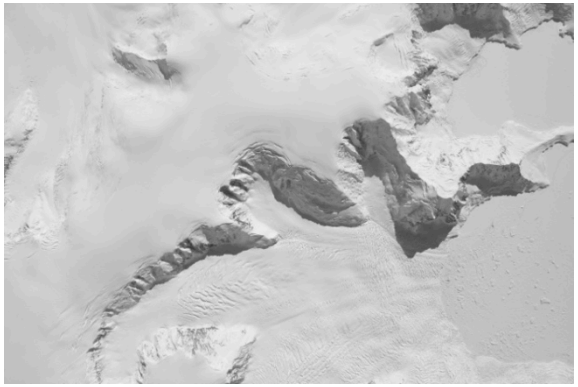

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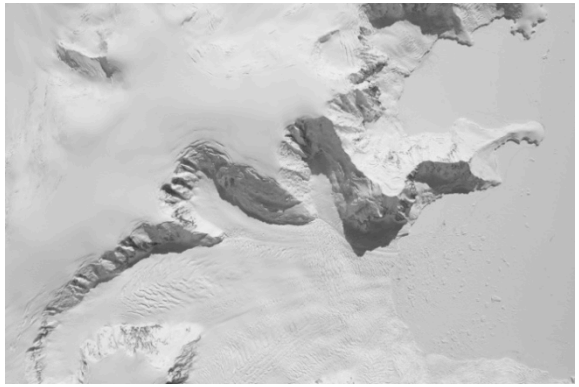

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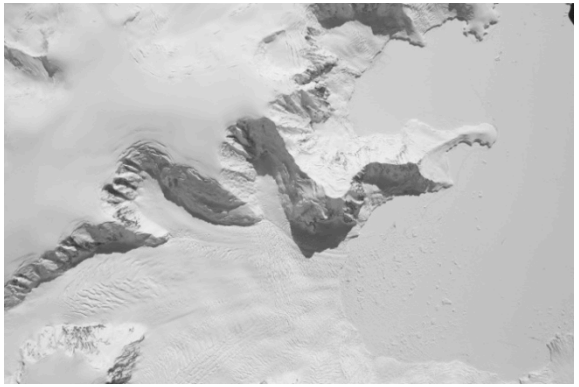
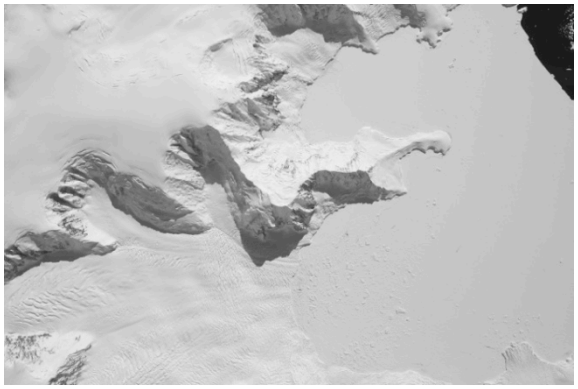


35,000' flight altitude

DMS Multi-view Coverage

Crane Glacier Flight

7



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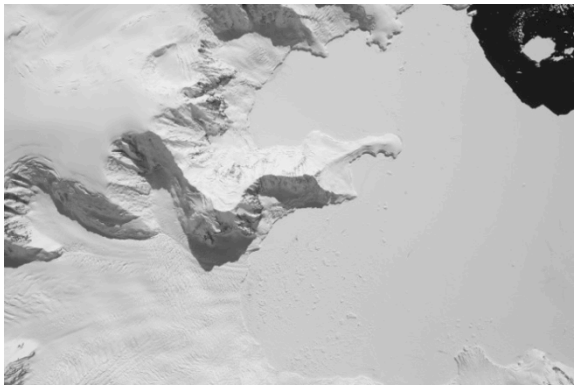

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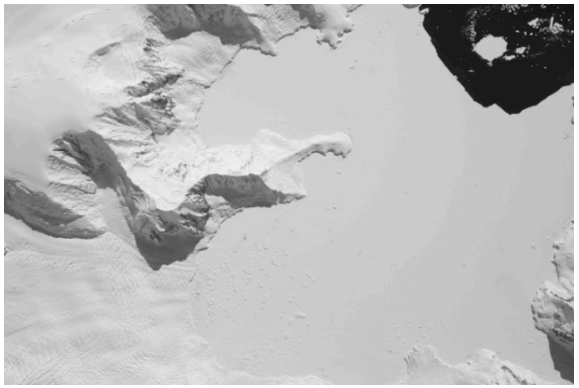

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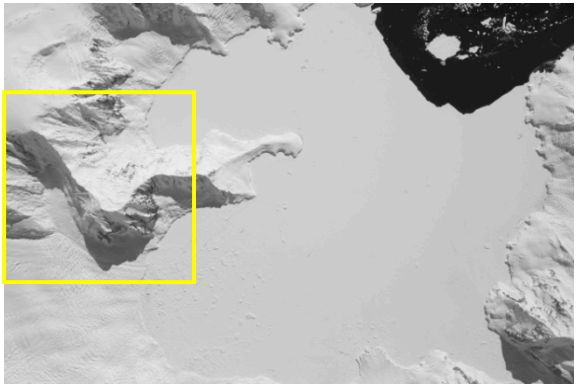

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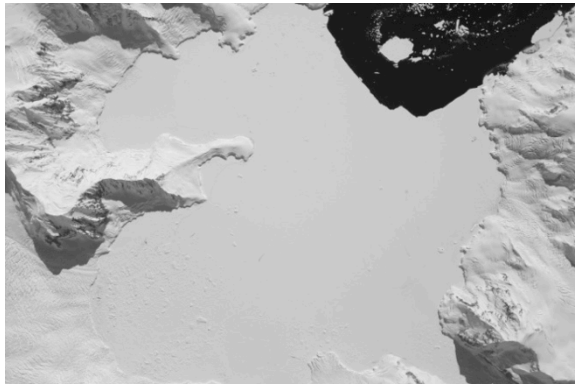

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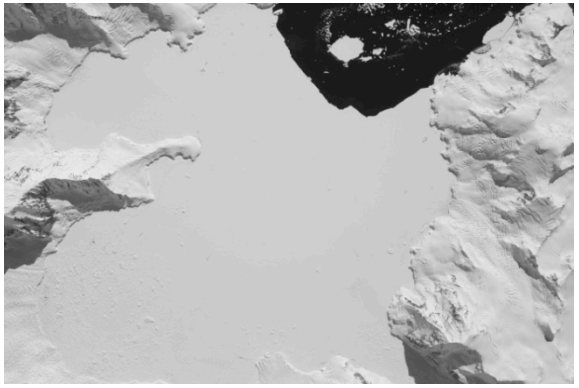


35,000' flight altitude

Parallax Example

full resolution

~60º parallax

Image 2

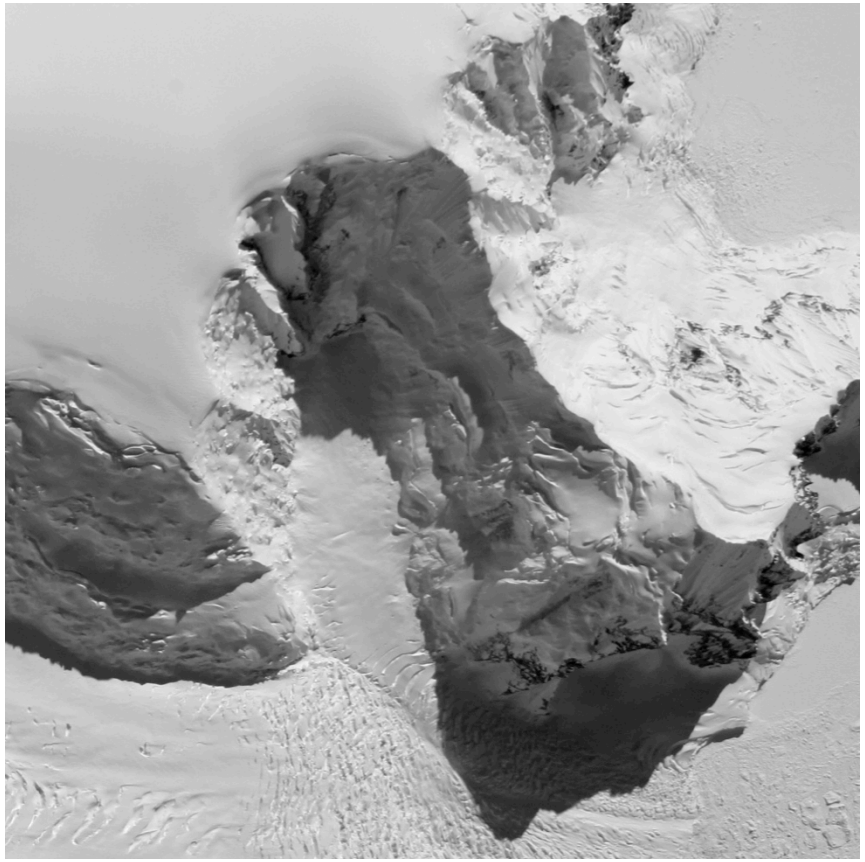
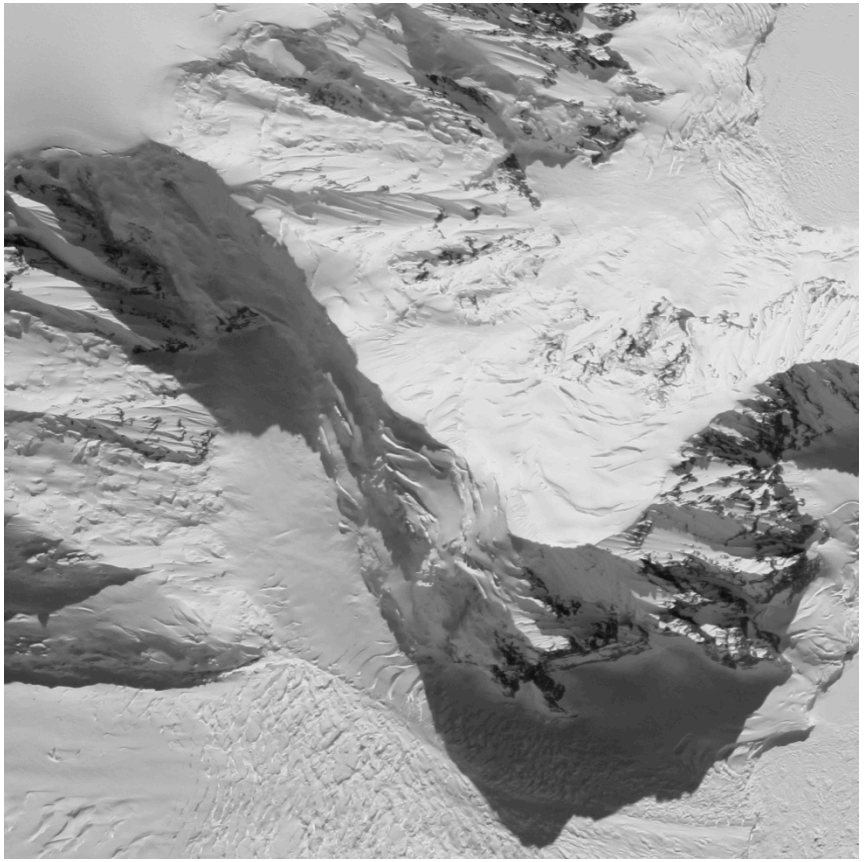


Image 10



35,000' flight altitude

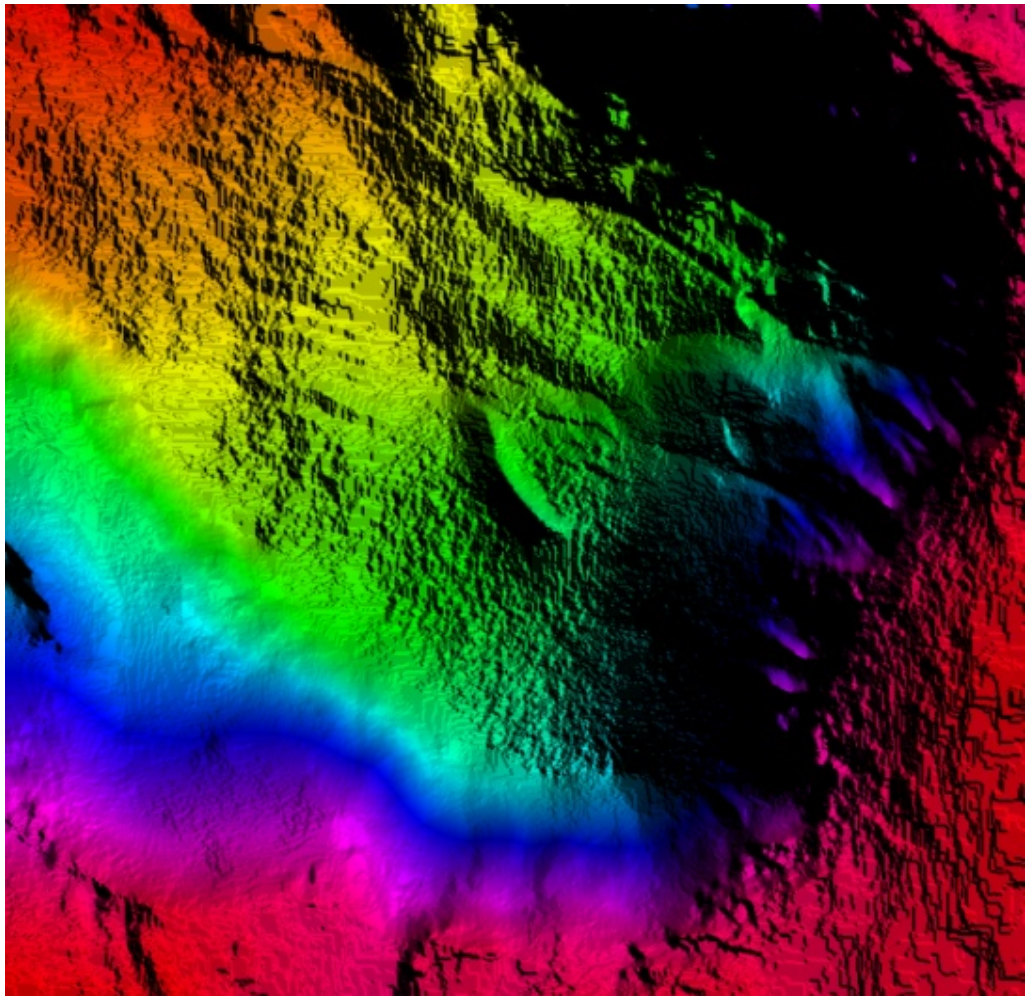
DMS Ice Bridge Applications

- Extraction of high-resolution DEM
  - Horizontal DEM posting at ATM flight altitude: ~20cm
  - Horizontal DEM posting at LVIS flight altitude: ~5m
  - Vertical resolution is approximately the same as above
    - Cannot match the vertical accuracy of LIDAR
- Creation of high-resolution 3-D imagery
  - Draping imagery over composite DEM will approach visual reality
  - Ability to “wander”, “fly” and “dwell” within the ice surface model

DEM Extraction from DMS

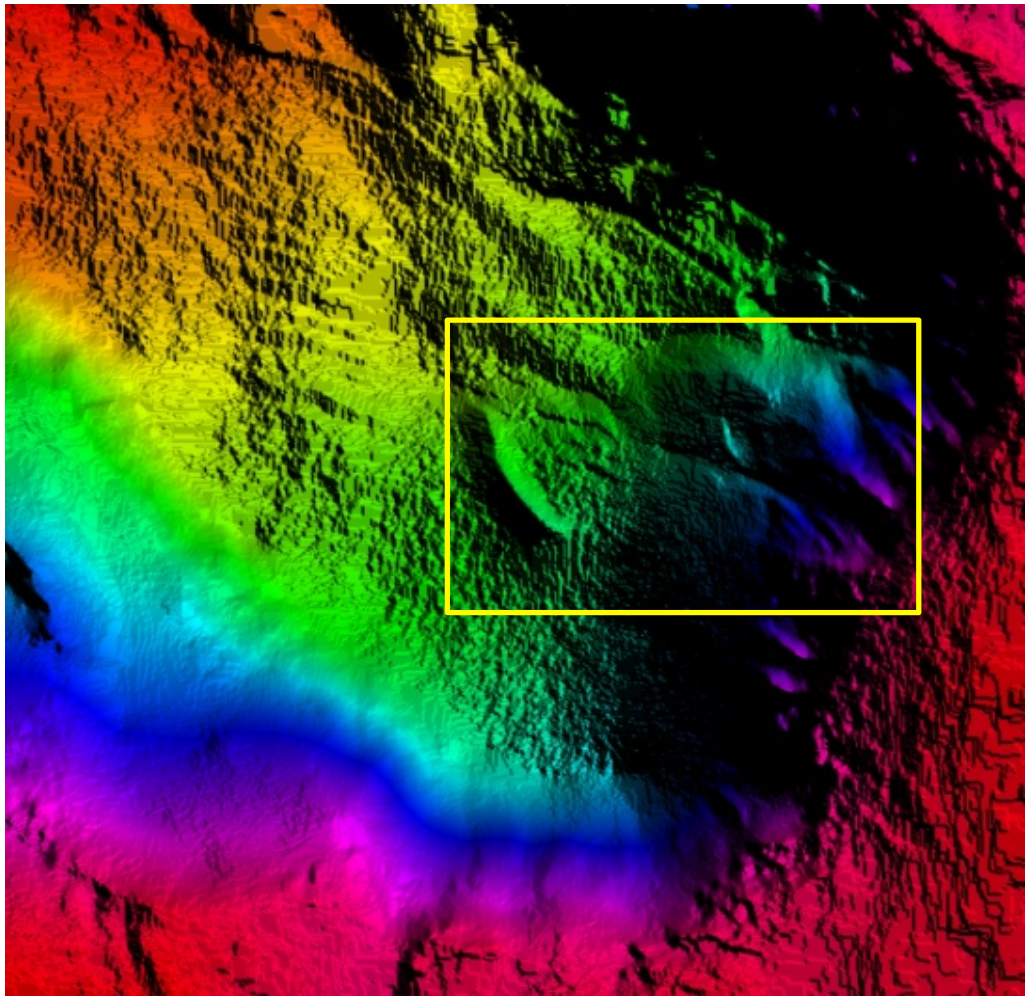
- Generation of high-resolution DEM
  - Fully automated procedure which estimates surface elevation at regularly spaced grid points
  - Estimate a 3D surface by globally minimizing a cost function
    - General Form:
    - **F(x, y, z) = P(x, y, z) + k·S(x, y)**
      - **P(x, y, z)** the "cost" of an unknown elevation at grid point (x, y). Based on photographic data (SSD, Cross-correlation).
      - **S(x, y)** represents a penalty term used to enforce surface smoothness. Based on local elevation differences.
      - **k** is a smoothness coefficient
  - Optimization is done in a probabilistic framework
  - Computationally expensive (CPU hours per km^2)

DEM Extraction from DMS



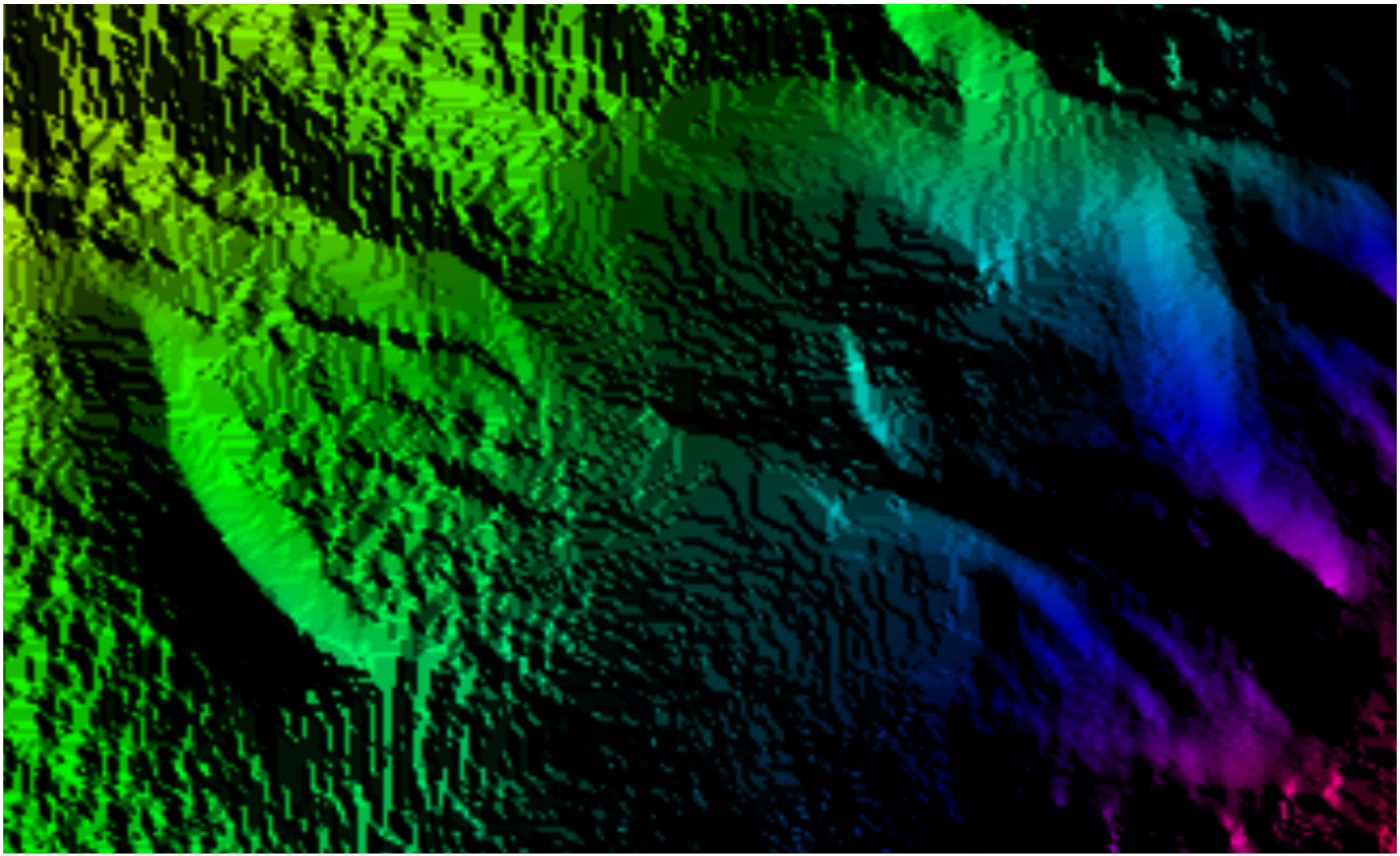
3km x 3km area from Crane Glacier @ 5m horizontal resolution

DEM Extraction from DMS

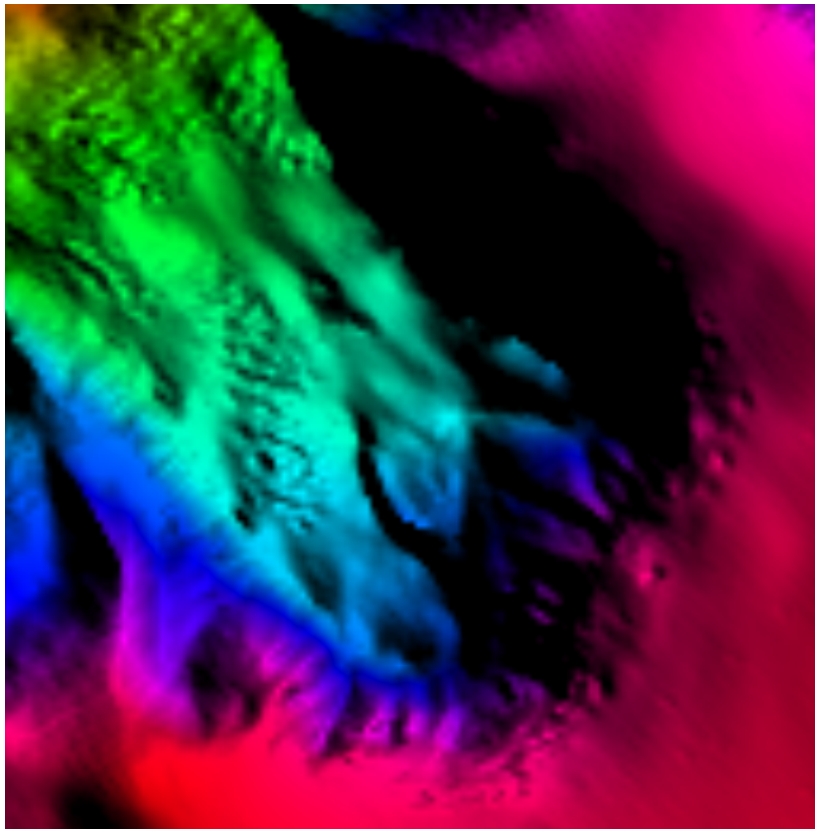


3km x 3km area from Crane Glacier @ 5m horizontal resolution

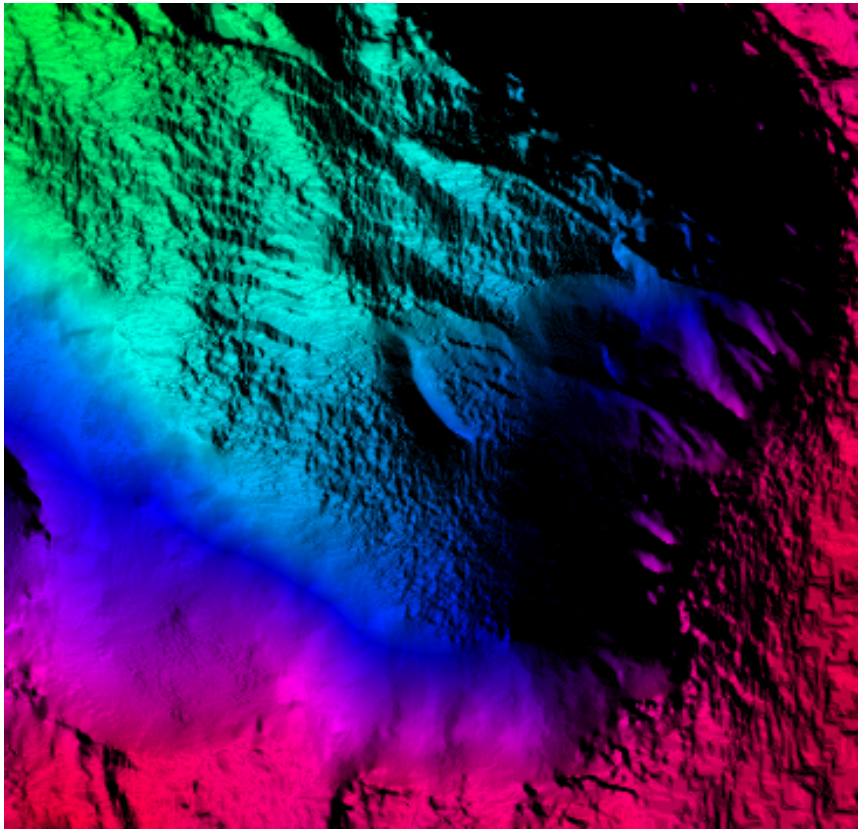
DEM Extraction from DMS



DEM Extraction from DMS



30m DEM Comparison



5m DEM from DMS

DEM Extraction from DMS

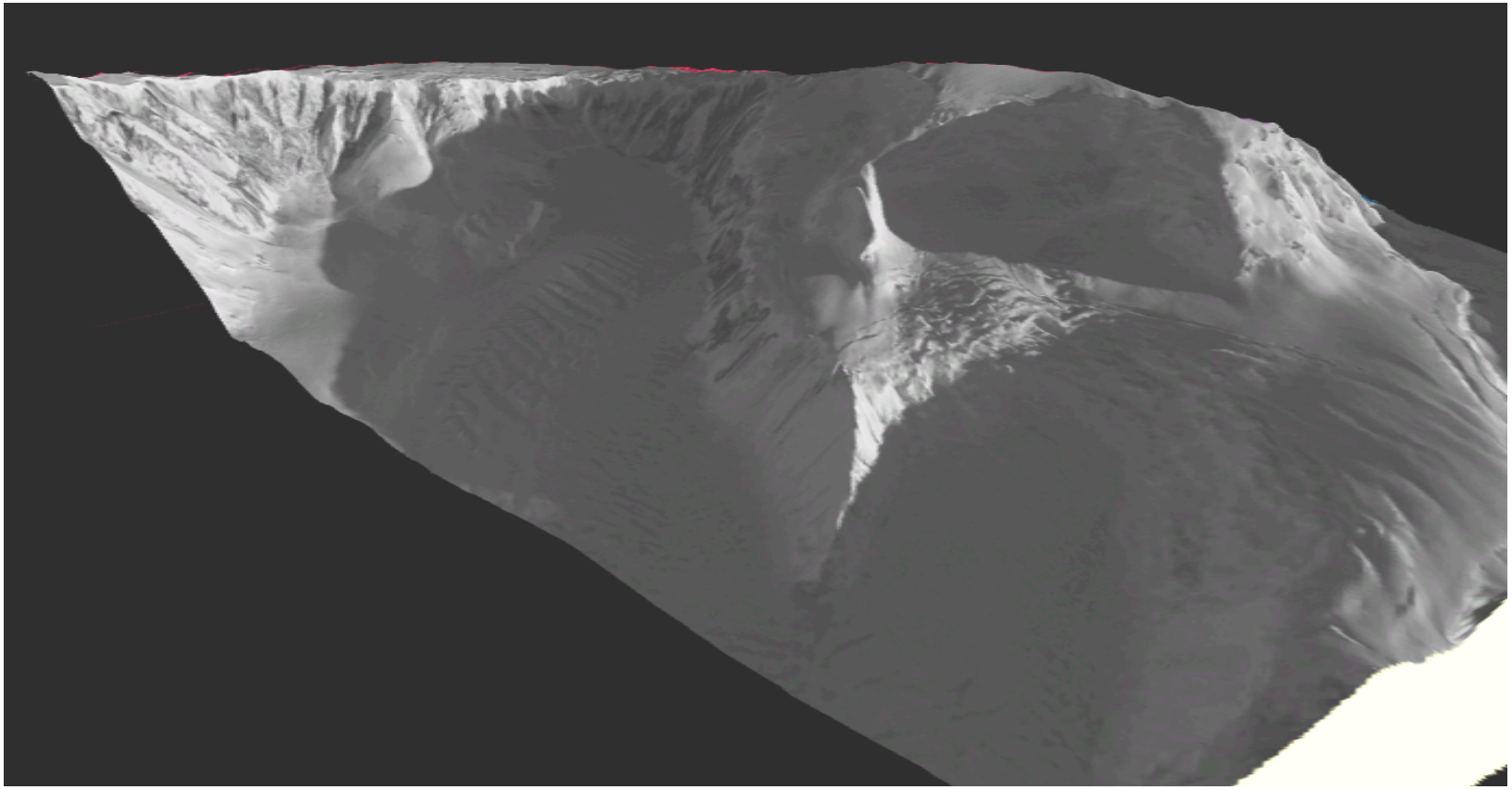


Image draped over DMS DEM

DMS Ice Bridge Applications

- Synergistic merging with LIDAR-derived DEM
  - Low cost and low programmatic impact to incorporate
  - Improved horizontal resolution of LIDAR-derived DEM
  - Improved interpolation across LIDAR posts

DMS Ice Bridge Applications

- Ice surface metrology
  - Statistical methods exist (ASME B46.1 and ISO 4287) to quantify surface roughness, surface texture and wavelength
  - A “roughness coefficient” can be generated from peak / valley height that could be used define the surface.

Ice Surface Roughness Variations

Examples: October 18 Pine Island Glacier Flight

Conclusions and Recommendation

- The multi-view capability of DMS can be used to generate a “reasonably” high-resolution DEM at low cost and impact
- This image-derived DEM should be able to be merged with a LIDAR-derived DEM to improve the LIDAR product
- The resulting “merged DEM” can be “draped” with imagery to create a realistic and accurate 3-dimensional scene
- Ice surface roughness can be quantified
- Existing and future Ice Bridge DMS data sets are ideal to apply this approach and should be fully exploited

Palmer Station Greeting

1000' flight altitude